



# Enhancements to RUC Land-Surface Model implemented in the 3.7 release of WRF model and in Land Information System (LIS)



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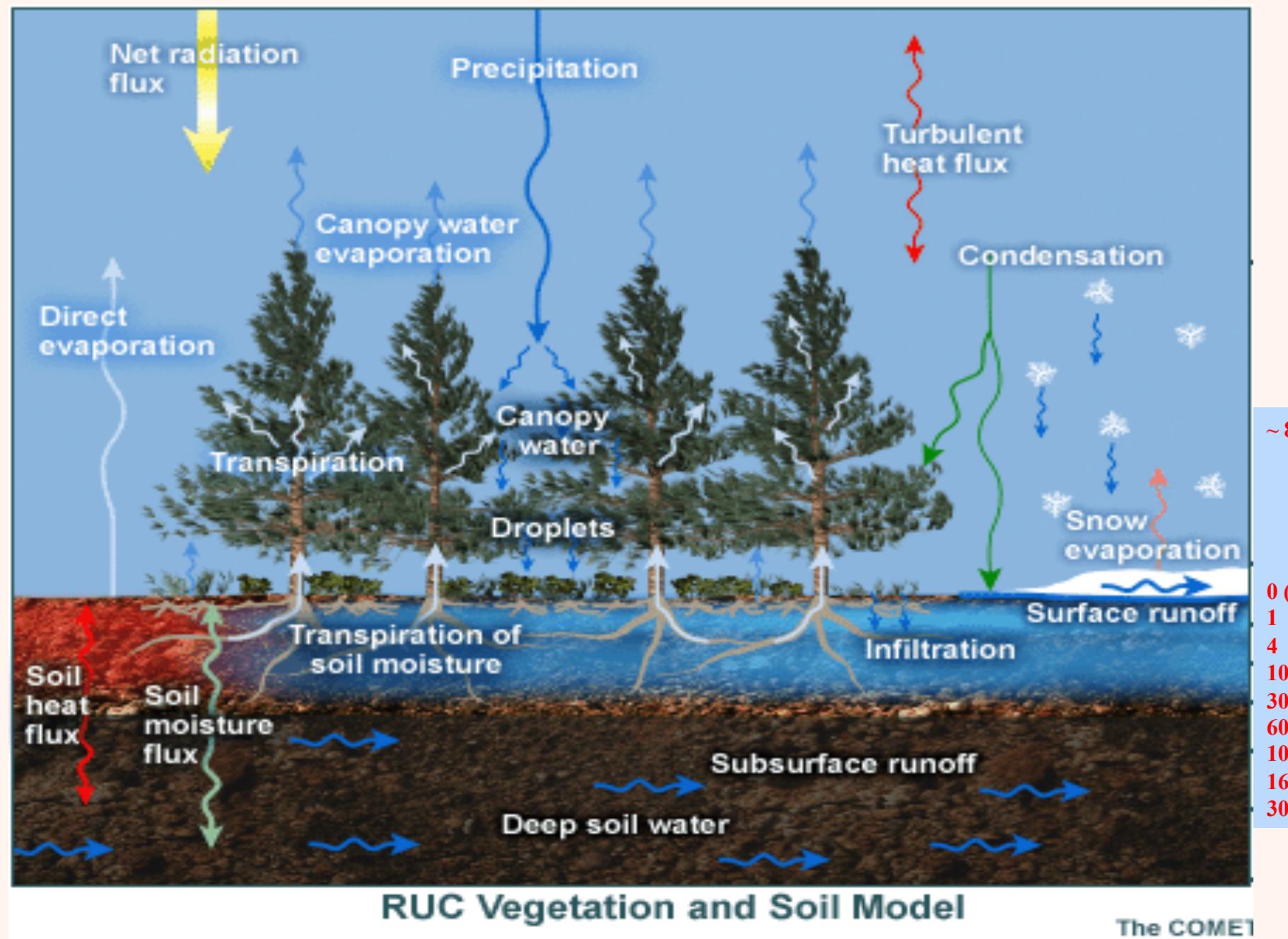
(1) NOAA Earth System Research Laboratory (NOAA/ESRL)  
 (2) Cooperative Institute for Research in Environmental Sciences (CIRES)

## RUC Land Surface Model (RUC LSM) implemented in:

- Operational RUC: 1998 – May 2012
- Weather Research and Forecasting (WRF) modeling system in 2002, used in WRF by non-ESRL researchers
- Operational Rapid Refresh (RAP) system using Advanced Research WRF (ARW) dynamic solver over North America domain with vast areas of Arctic sea ice:
  - version 1 - May 2012; version 2 - February 2014;
  - version 3 - Fall 2015; (<http://rapidrefresh.noaa.gov>)
- Operational High-Resolution Rapid Refresh (HRRR)
  - version 1 – September 2014
  - version 2 – Fall 2015 (<http://rapidrefresh.noaa.gov/HRRR>)
- NASA Land Information System (LIS) – work in progress

## Main characteristics of RUC LSM

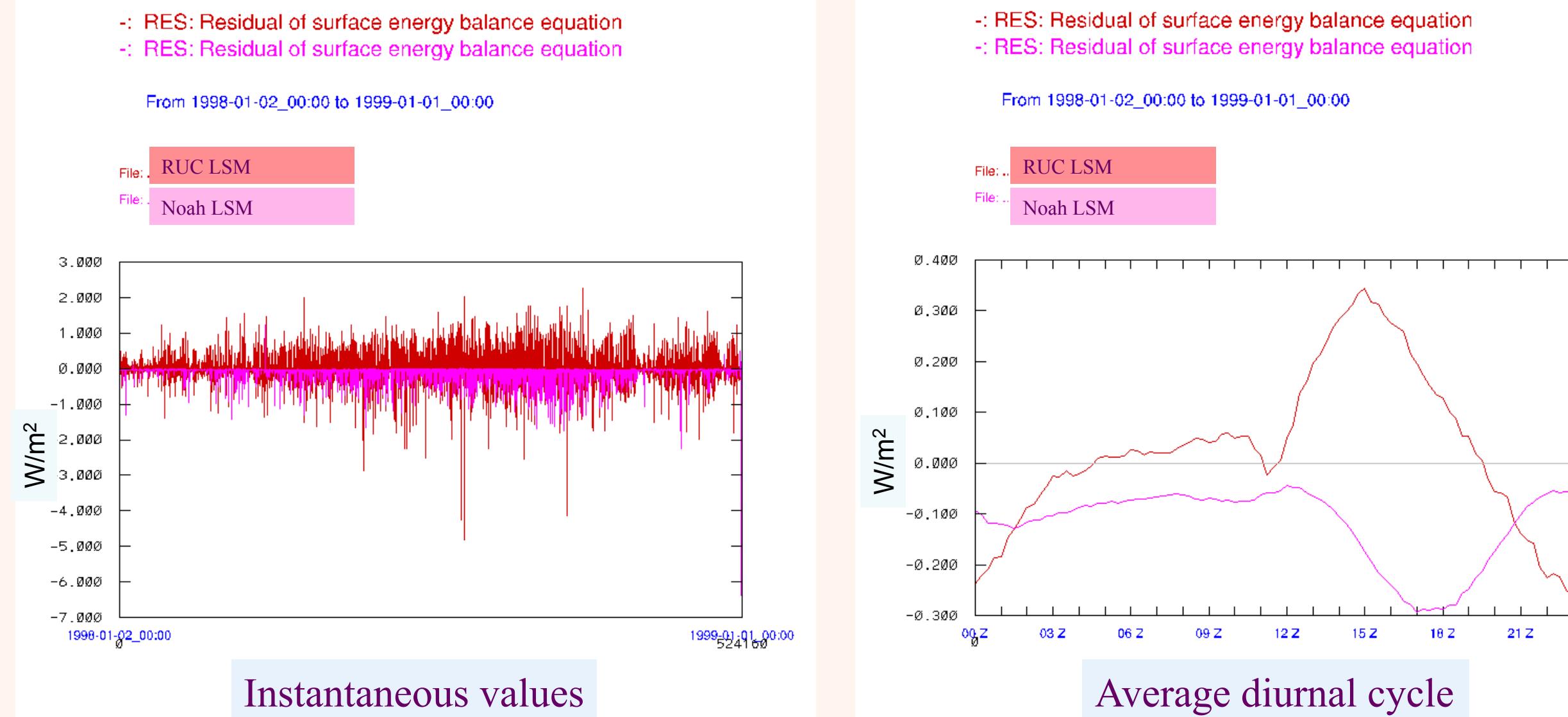
- Implicit solution of energy and moisture budgets
- Multiple soil levels with high vertical resolution near surface
- 2-layer snow model with iterative snow melting algorithm
- Treatment of mixed phase precipitation
- Simple but effective frozen soil physics algorithm



## Changes to RUC LSM in 3.7 version of WRF

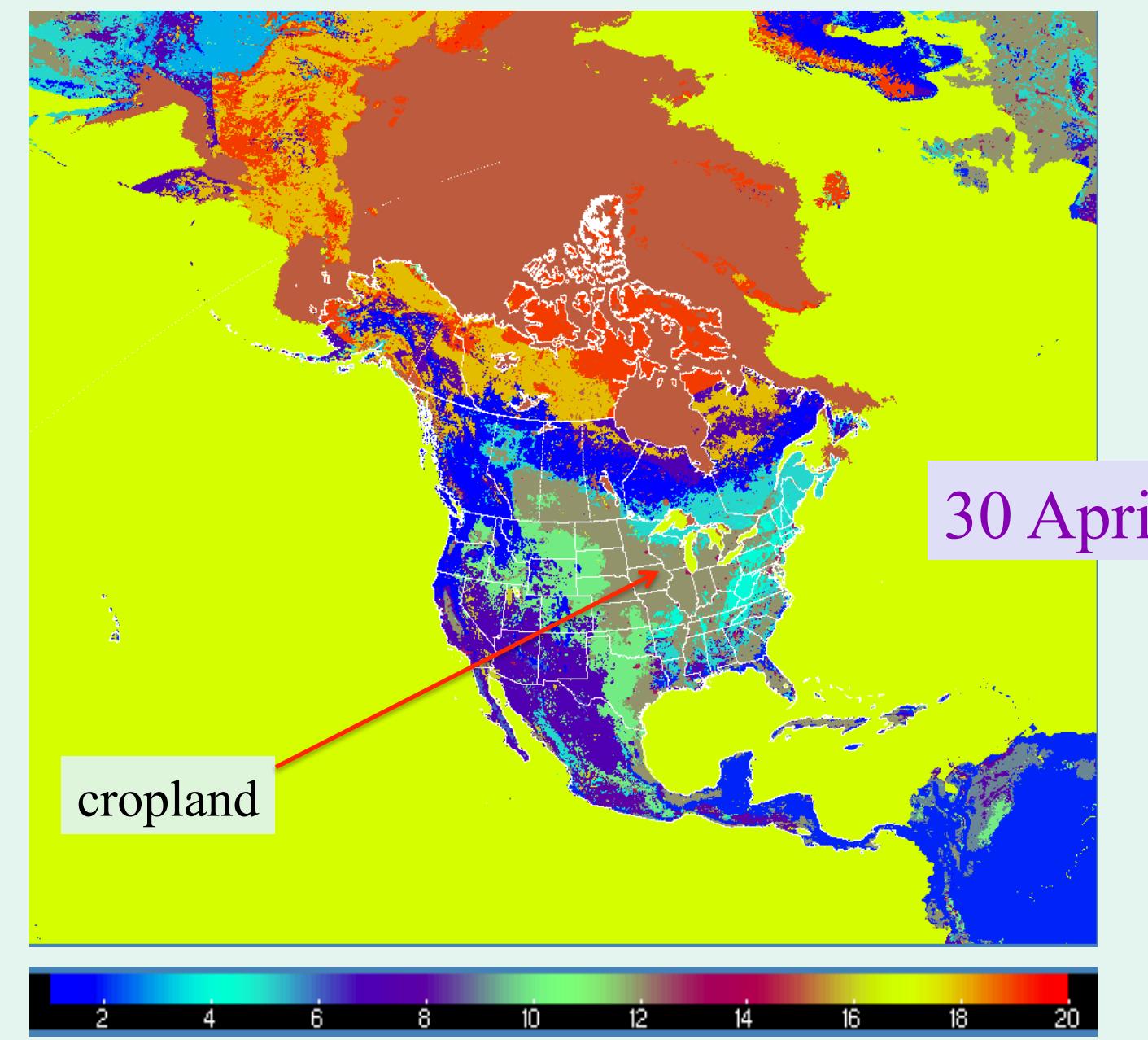
1. Simple treatment of cropland irrigation during the growing season;
2. Mosaic approach to snow-covered and snow-free portions of the grid cell;
3. Ensured energy and moisture conservation, added necessary variables for energy and moisture budget research.

## 3. Residual of surface energy budget for Bondville, IL (1998 dataset) (LIS implementation testing is underway)

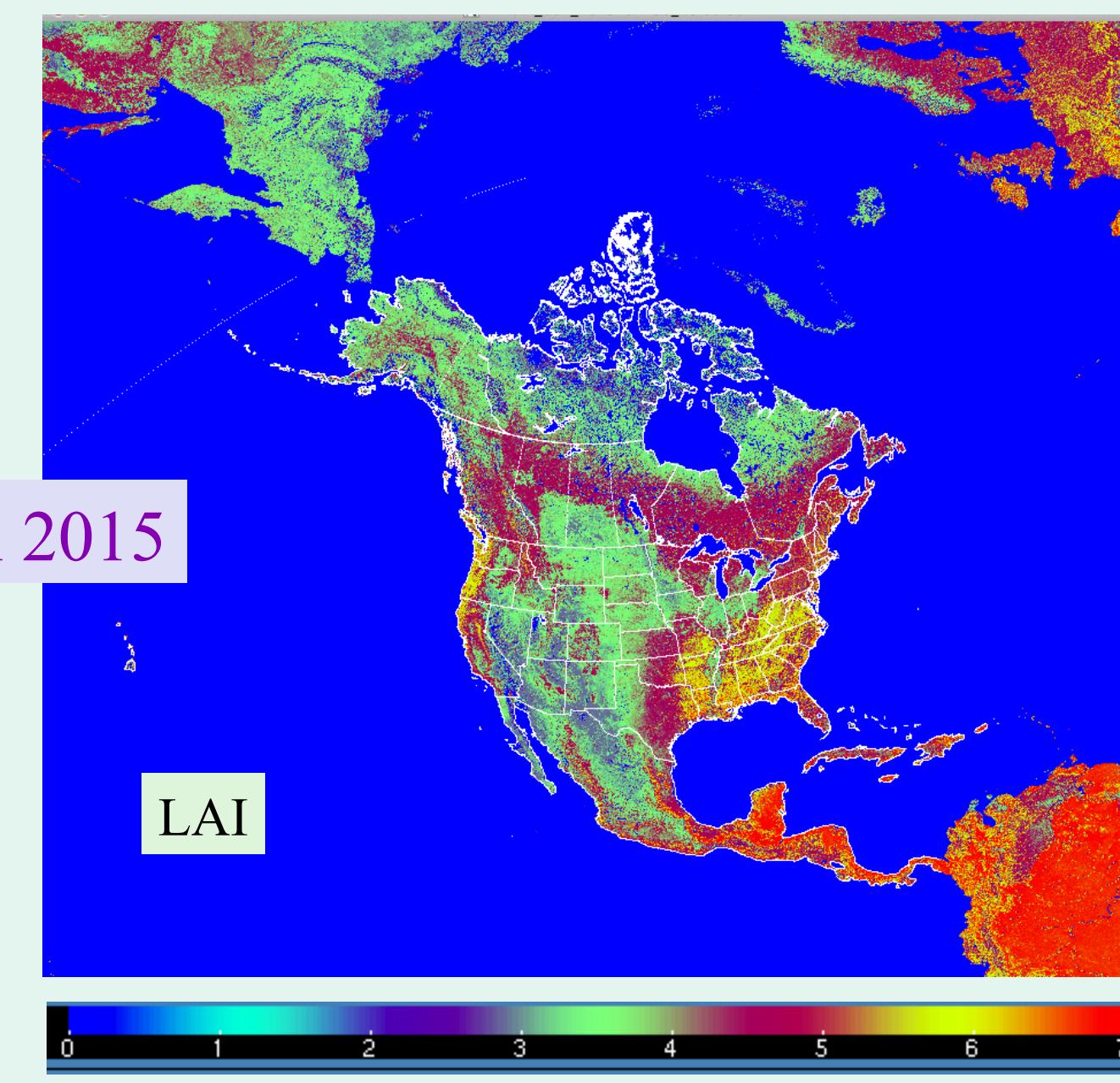


## 1. "Irrigation" treatment during the growing season

### 30" MODIS Land-use



### Leaf Area Index (LAI)



## RUC LSM assumptions:

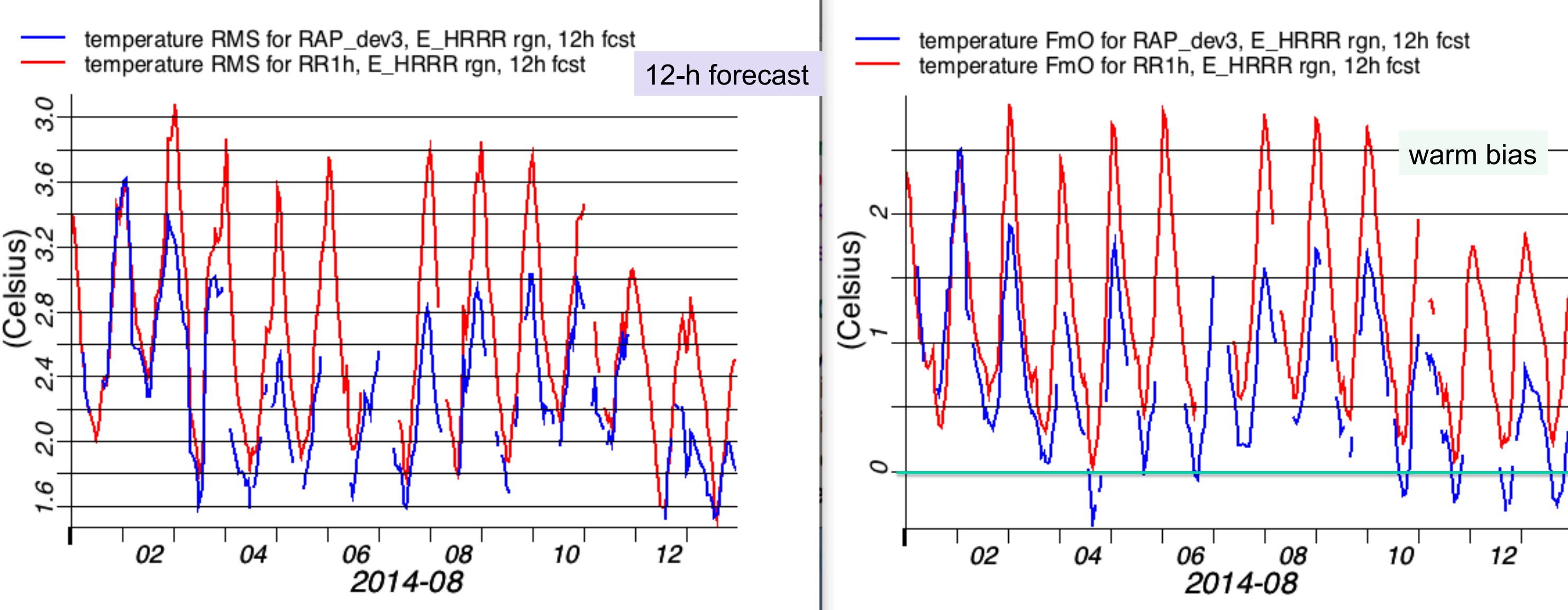
- ✓ During the crops growing season simple irrigation treatment keeps model soil water content above the wilting point value for a given soil type;
- ✓ Use  $\text{LAI} > 1.1$  criterium to define the growing season;

## Applied to:

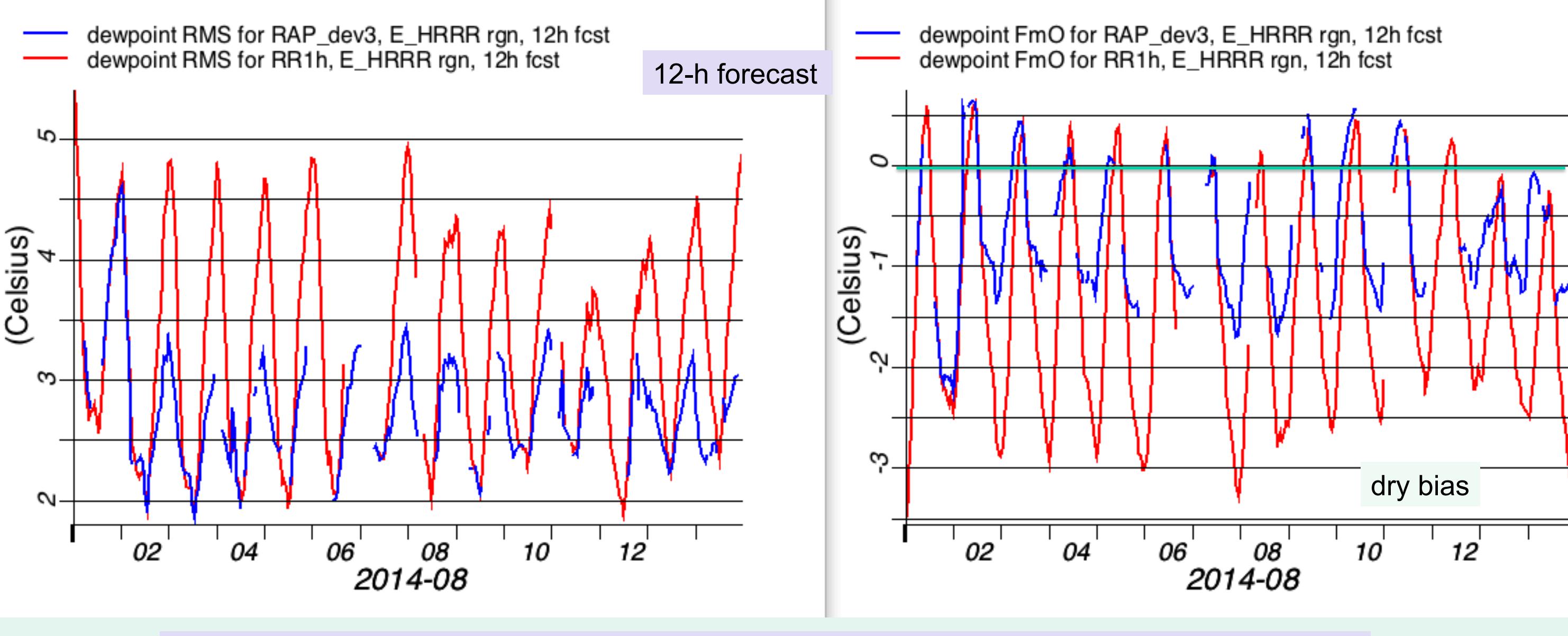
- Portions of grid cells with cropland category;
- 40% of grid cells portion with grassland category;

➤ Implemented in experimental version of RAP (RAP\_dev3) on 3 August 2014 to reduce dry/warm biases in the Eastern US

## 2-m temperature RMS errors (left) and biases (right)



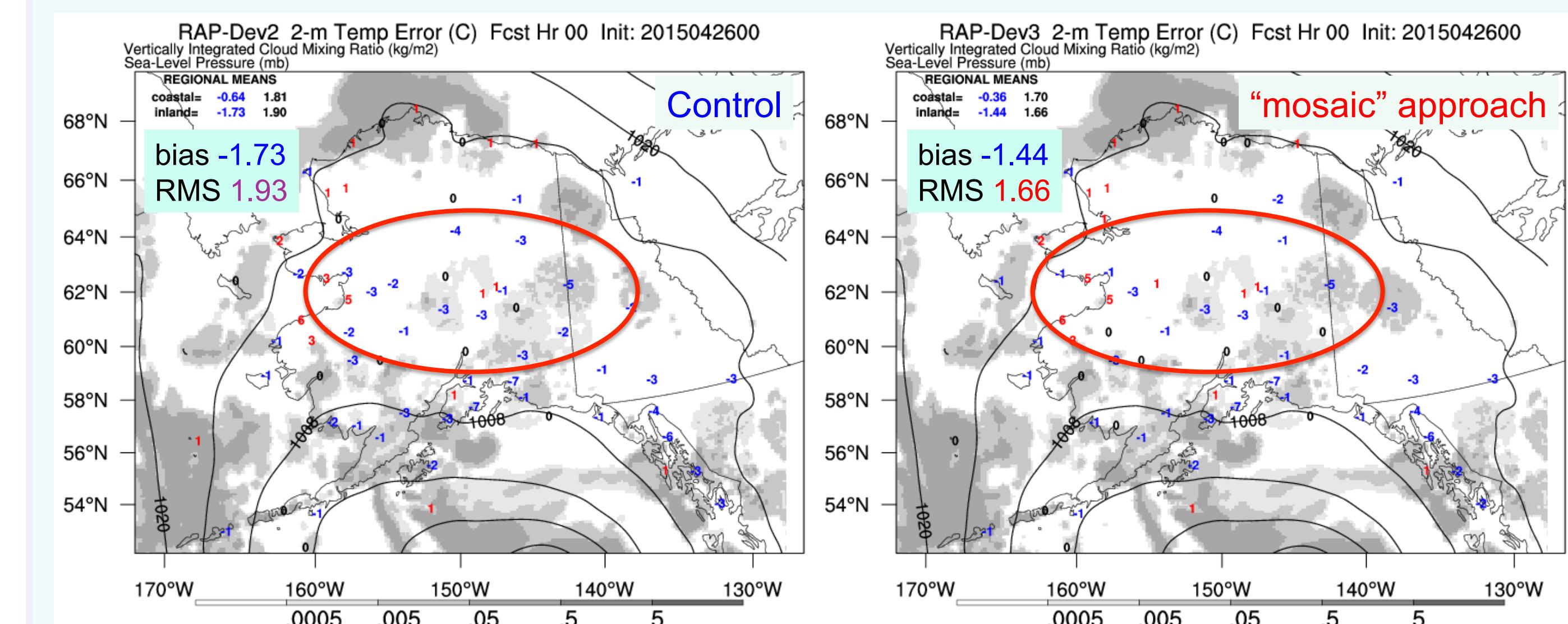
## 2-m dewpoint RMS errors (left) and biases (right)



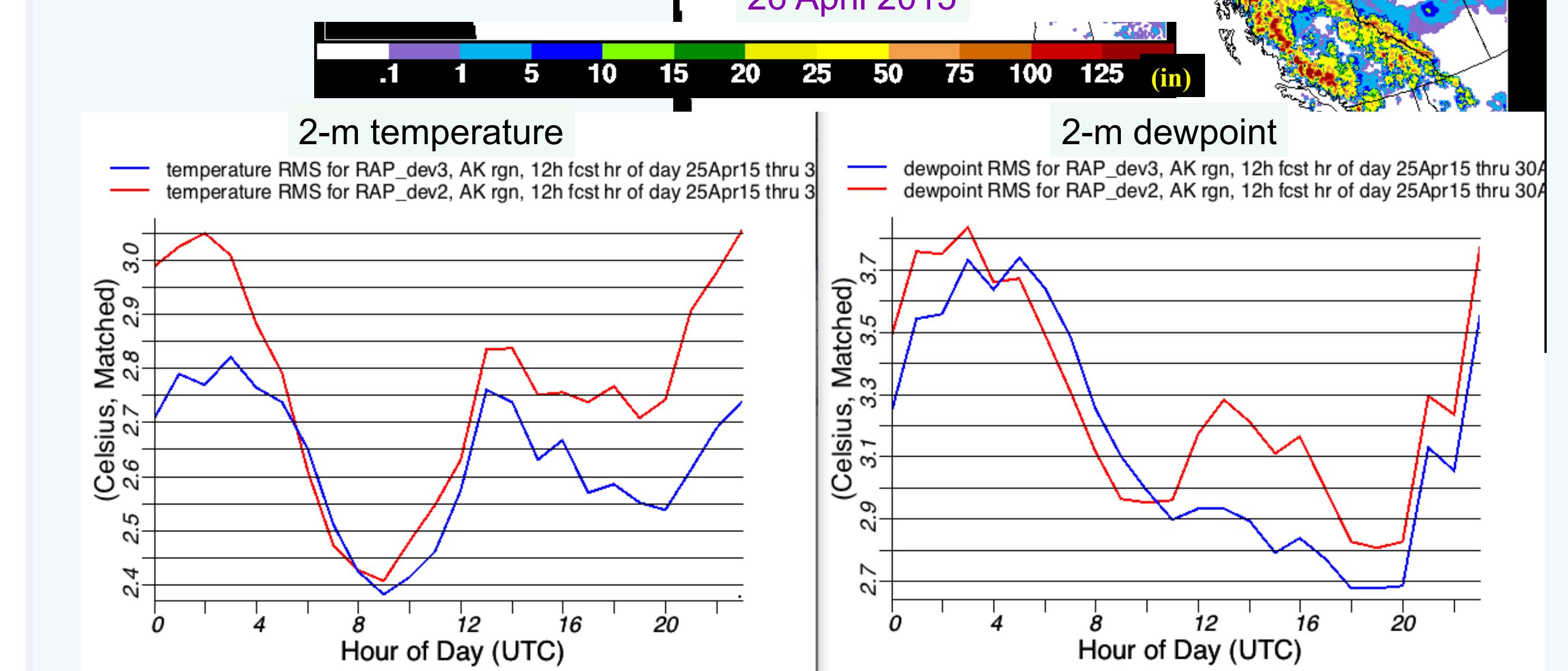
➤ RR1h – control; RAP\_dev3 – uses simple irrigation treatment

## 2. "Mosaic" approach to snow model:

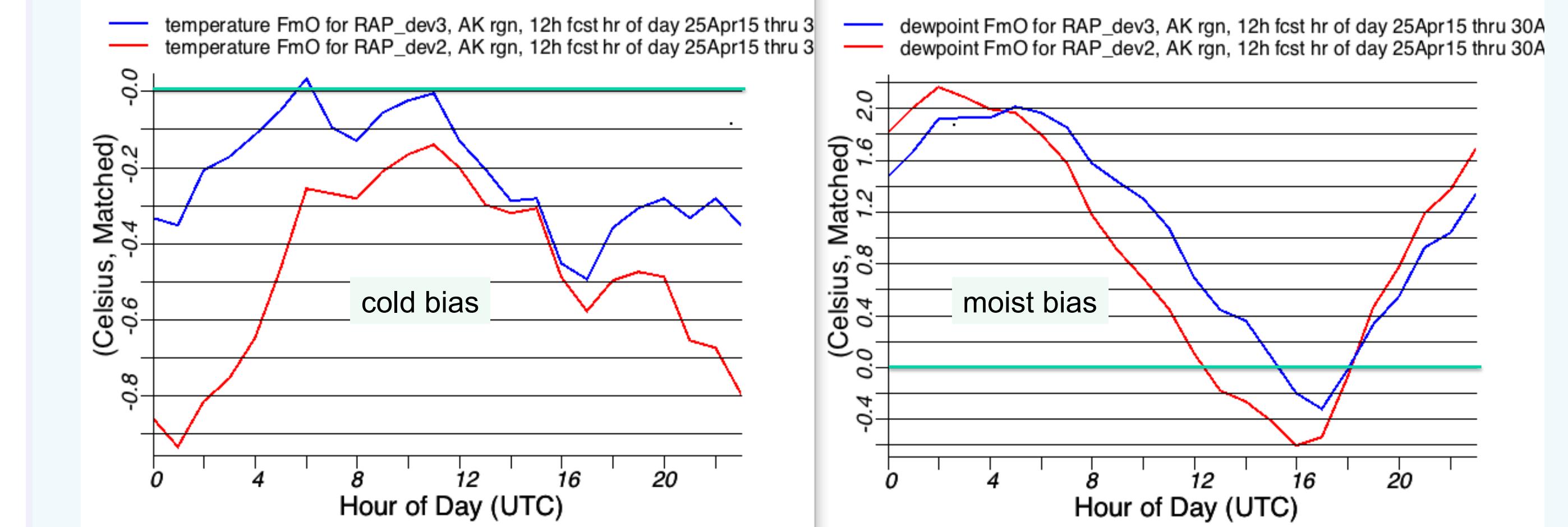
- Separate solutions of energy and moisture budgets of snow-covered and snow-free portions of the grid cell;
- Aggregate solutions at the end of time step;
- Snow fraction defined from the ratio:  $\text{snhei}/\text{snhei\_crit}$ , where  $\text{snhei\_crit} = \text{snow\_density} * 0.016 [\text{m}]$



- "Mosaic" approach applied to snow areas inside the red oval;
- reduced cold biases;
- Improved 2-m dewpoint during the daytime.



Diurnal cycle of 12-h forecast RMS errors (above) and biases (below) over Alaska averaged for 25-30 April 2015



➤ RAP-dev2 – control; RAP\_dev3 – uses "mosaic" approach

## CONCLUSIONS:

2015 RUC LSM modifications implemented in WRF-based RAP and HRRR resulted in improvements in surface predictions over snow:

- reduced cold biases of 2-m temperature;
- reduced RMS errors for 2-m temperature and dewpoint